41.6° at Pompeii, Oreg. The highest temperature recorded was 106° at Kennewick, Wash., on the 11th, and the lowest 15° on the 4th, at Cliff, Oreg.

PRECIPITATION.

The precipitation was decidedly below the normal in the western portion of the district. A slight deficiency was reported in eastern Washington, extreme northern Idaho, and in northeastern Oregon. In central and southern Idaho and western Montana the precipitation was unusually heavy, in marked contrast with the light rainfall of June, 1910, in this section. Monthly amounts of more than 4 inches were reported from a number of stations.

The precipitation was distributed throughout the month in the form of frequent light showers in Montana and Idaho, there being few days on which some portion of these States received no precipitation. In Oregon and Washington there were no general rains during the first two decades, and showers were infrequent. During the last 10 days, however, general rains occurred over both States. The heaviest 24-hour rainfalls in all parts of the district were recorded during the last week.

The average for the district, as determined from the records for 354 stations, was 1.67 inches, which is 0.20 inch below the normal amount for June. The greatest monthly amount recorded was 5.64 inches, at Middle Fork, in north-central Idaho. At Mountain Ranch, in southwestern Oregon, no precipitation was recorded during the month. The greatest amount in 24 hours was 2 inches, at Columbia Falls, Mont., on the 24th. Other heavy 24-hour falls were: 1.99 inches at Queets River, Wash., on the 26th, and 1.83 inches at Quiniault, Wash., on the 26th.

THE RIVERS.

Excepting the Willamette and its tributaries, the rivers throughout the district were higher than in May, the annual rise which occurred in the Columbia making the increased stage in this stream very pronounced. The Snake River was above the normal for June, but other rivers in the district were below normal.

The Columbia River averaged 22.7 feet, which is 1 foot below the normal for the month, there being no departure at The Dalles and a difference of −3.3 feet at Cascade Locks. The highest stages occurred between the 17th and 22d of the month in a majority of cases, and the lowest on the 1st and 2d. Compared with the mean stage for May the average was 8.7 feet higher.

The Willamette River averaged 6.2 feet, which is 0.5 foot below the June normal; it was 0.5 below the normal at Portland, and 0.7 below at Salem. The mean stage at Portland was 5½ feet higher than in the preceding month, owing to the annual rise in the Columbia and the backwater therefrom in the lower Willamette. The extremes of high and low water occurred generally during the first and last weeks of the month, the highest stage reported being 19.2 feet at Portland on the 20th (this date being the exception for maximum readings on the Willamette) and the lowest 0.3 foot at Harrisburg on the 26th.

The Snake River averaged 12 feet, which is 1.3 feet above the normal. The highest stage reported was 15.6 feet at Lewiston on the 14th, and the lowest 7.8 at Weiser on the 1st.

By loading boats with only moderate cargoes it was found possible to cope with the stronger current attending the June rise in the Columbia, and navigation continued uninterrupted on this stream throughout the month. The Oregon City Transportation Co. stopped operating boats above Salem on June 15, due to falling water in the Willamette. The backwater from the Columbia caused high water in the Willamette River at Portland during the greater part of the month, the flood stage of 15 feet being reached on June 7 and exceeded for the remainder of the month. The lower floors on all the docks had to be vacated, but no damage of any importance was sustained.

MISCELLANEOUS.

Heavy frosts occurred within the State of Oregon on a number of dates, and solar and lunar halos were observed in many places on the 4th, 11th, and 14th.

Thunderstorms and hail were of frequent occurrence throughout practically the entire district. They were particularly general on the 12th, 13th, and 20th.

The prevailing direction of the wind over the greater portion of the district was southwesterly.

DUTY OF WATER INVESTIGATION IN IDAHO.

By DON H. BARK, Irrigation Engineer, in charge United States Irrigation Investigations in Idaho.

Although the development of irrigation has been very rapid in the West during the past decade there are still left millions of acres of arid land that can never produce profitable crops without irrigation. The water supply, though large, is not unlimited, yet it is the one factor that will determine the extent of our ultimate irrigated area. The available supply is now nearly all appropriated, and the only method by which more land can be brought under irrigation in those regions possessing too scanty a rainfall to produce crops by the so-called dry farming methods is by increasing the area which a given quantity of water now serves and by the conservation and utilization of the water that is now wasted.

The allotments of water used for irrigation purposes throughout the West vary considerably. Some allotments call for enough to cover the land 30 feet deep during the season, while others will supply only 1 foot in depth to the land during the same period. These variable allotments have been made without due consideration for the soils in question. Many times as good or better crops could be produced with less than half of the water now used. It is vitally important that our water be put to the best use if we are to secure the best results from the annual flow from our watersheds. The allotments of the past have been based to too great an extent upon the practice of irrigators who were far from careful, hence they are, in many cases, far too large; but as time has passed water has risen in value so rapidly that we are now prone to increase the area very materially that will be supplied by a given quantity. New projects are being opened up from time to time and it is of vital importance that the proper and economic amount of water be allotted for the use of the settlers who secure these lands. If too small an allotment is made maximum crops can not be produced, thousands of settlers will suffer and the land can never reach its highest possible value, while if more than necessary is allotted our ultimate irrigated acreage will be seriously cut down.

Different soils and crops require different amounts of water, but just how much more or less this is has never been definitely known. It is certain that a better knowledge must be obtained of the water requirements of these different soils and crops before much can be done toward the establishment of the proper duty for the large projects of the future.

The need for a better knowledge of the water requirements of crops has long been felt, and principally for the above-mentioned reason an agreement was entered into between the State board of land commissioners of the State of Idaho and the irrigation investigations branch of the United States Department of Agriculture late in the fall of 1909 for the carrying on of an extensive duty of water investigation. The author, under the direction of Dr. Samuel Fortier, chief of irrigation investigations, has had charge of the planning and carrying out of this investigation within the State of Idaho. The investigation was started in a practical way early in the spring of 1910, during which year the water was measured on a large number of typical farms throughout the State, and it is expected to continue the investigation for at least three seasons along the same practical lines as those pursued during 1910.

METHOD OF CARRYING ON THE INVESTIGATION.

About 60 tracts, ranging in size from 5 to 100 acres, were selected on average farms in typical irrigated districts of the State, namely: (1) Upper Snake River Valley, (2) Middle Snake River Valley, including Wood River, and (3) Boise Valley. These tracts were planted to oats, spring and winter wheat, barley, clover, alfalfa, and potatoes, and represent all classes of soils and topography, together with the various systems of irrigation common to Idaho. The investigation thus covers 300 miles of the Snake River Valley with altitudes ranging from 2,400 to 5,800 feet, and it is certain that with a careful compilation of so much data covering such a diversity of conditions, results can be worked out that will be of vital and far-reaching importance to any one interested in irrigation.

About 10 assistants, skilled in the measurement of water, were employed and each one was given supervision of from four to six of the tracts. Each tract investigated was divided into three nearly equal parts, the owner being allowed to irrigate one of them at such times and using such amount as had been his usual custom, which amount was carefully measured through Cippoletti weirs by the assistant in charge of the experiment, after which the other two tracts were irrigated by applying less during the season to one and more to the third than had been applied by the owner. Thus, there were in each case, three tracts of the same class of soil all planted to the same crop and at the same time, all conditions being similar, except that different amounts of water were applied to each tract during the season, and it is comparatively easy to determine at the close, after weighing the yield, which amount of water is the most beneficial to apply to the soil and crop under the existing conditions. Careful moisture determinations are made of the soil on each plot about the beginning of the growing season before the first irrigation is applied, which aids materially in the comparison of the results from the different plots. A careful classification of the soil of each tract was made to at least a depth of 4 feet and average samples of the first, second, third, and fourth feet of soil from each plot have also been taken and are now stored away for future reference. All feed and waste water is measured through carefully constructed Cippoletti weirs and the amounts tabulated herein represent only those absorbed and utilized by the fields in question. All data which may have any bearing on the crop yield or the duty of water have been carefully observed and will be taken into consideration when the results are tabulated.

The precipitation during the growing season of 1910 was the lowest on record. For seven consecutive months, or from March to September, inclusive, the rainfall over the entire southern part of the State was much below normal. The precipitation, however, during the early part of the growing season of 1911 has been much above normal and it is fully expected that much less water will be required than during the past season, but it is thought that the average of the amounts required during the two years will very nearly approach the proper duty for the soils and crops under observation.

The results secured during the season of 1910 are all given in detail in the last biennial report of the Idaho State engineer and the results in the following table selected from those in the published report represent typical average conditions in typical districts throughout the State.

A brief summary of the 1910 investigations.

Location.	Crop.	Area.	Class of soil.	Number of irrigations.	Depth applied.	Yield per acre.
		Acres.			*Feet.*	
Meridian	Alfalfa	5.08	Sandy loam	6	2.821	5.15 tons.
Nampa	do	6.32	Impervious lava ash.	7	1.434	2.85 tons.
		6.23	do	7	2.112	4.93 tons.
		6.21	do	7	2.251	4.35 tons.
Caldwell	do	2.81	do	8	1.90	4 tons.
		3.69	do	8	2.84	3.66 tons.
		2.84	do	9	3.45	4.37 tons.
Boise	Oats	3.61	Sandy loam	3	1.00	58 bushels.
		2.77	do	5	1.36	55 bushels.
		2.57	do	5	2.31	47 bushels.
Richfield	do	3.91	Typical lava ash	3	2.12	22.8 bushels.
		3.73	do	4	2.20	27.7 bushels.
		4.51	do	5	3.31	27.6 bushels.
Gooding	Alfalfa	5.75	Medium lava ash	2	1.31	3.3 tons.
		3.72	do	3	1.87	3.56 tons.
		3.56	do	3	2.10	4.74 tons.
Buhl	Spring wheat	4.95	Deep lava ash	1	.87	44.5 bushels.
		5.06	do	2	1.44	67 bushels.
		5.06	do	3	2.20	59 bushels.
Gooding	Alfalfa	9.83	Medium lava ash	6	4.49	8.7 tons.
Idaho Falls	Oats	3.46	Impervious lava ash.	3	.99	44.5 bushels.
		3.44	do	3	1.22	49.7 bushels.
		3.66	do	3	1.71	54.3 bushels.
Rigby	Alfalfa	10.65	Very gravelly	9	11.20	4.2 tons.
Do	do	2.33	do	4	6.35	3.78 tons.
		6.77	do	6	6.93	4.85 tons.
		2.51	do	7	9.40	4.60 tons.
Do	Wheat	3.60	Gravelly	3	2.63	30 bushels.
		3.16	do	4	3.10	35.8 bushels.
		3.07	do	5	3.95	30 bushels.
Do	Clover	3.31	Very gravelly	7	6.92	3.78 tons.
		4.32	do	9	8.40	4.85 tons.
		3.98	do	10	11.47	4.60 tons.
Ketchum	Alfalfa	15.84	Gravelly	......	21.13	3.5 tons.

Some very interesting data as to the amount of water required during different parts of the season have been worked out from last season's investigation, and it is thought these will be of interest to all irrigation engineers and especially to those interested in the designing of storage projects. While sufficient data have not been collected from which to establish a definite duty, it is quite certain that the percentages which were applied during the different months will not vary materially even though the total amounts used may be higher or lower than the average of those used in the investigation. The following tables have been compiled from the measurements obtained during 1910 after eliminating those plots which had plainly received too much or too little water for the production of profitable crops.

Summary of water applied by months to 56 fields of alfalfa and grain on the medium lava ash and clay soils.

Crop.	Apr. 1–15	Apr. 15–30	May.	June.	July.	Aug.	Sept. 1–15.	Total.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Alfalfa	0.053	0.018	0.531	0.720	0.602	0.551	0.0636	2.54
Grain	....	....	.320	.6453	.495	.0954	....	1.556
Average	.0265	.009	.4255	.6826	.548	.3232	.0318	2.048
Percentage of total	1.3	0.45	20.78	33.34	26.79	15.78	1.56	100.0

This table shows strikingly that the greatest need for irrigation water on the medium lava ash and clay soils falls during the month of June when one-third of the total amount used during the entire season was applied. These amounts represent those which were actually applied to and absorbed by the fields in question, and no allowance has been made for the seepage in canals or general loss in transmission.

If an entire project were to be taken into consideration, due allowance must be given to these factors. There would also be a somewhat greater demand for water both early and late in the season to provide for stored water and that used for domestic purposes, as well as for fall grains and young alfalfa, which were not included in this investigation but which would need a comparatively small amount of water during the fall months.

Summary of water applied, by months, to 26 fields of grain and hay on porous sandy and gravelly soils.

Crop.	Apr. 15–30.	May.	June.	July.	August.	Total.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Alfalfa	0.372	1.723	1.61	1.743	1.68	7.13
Grain	....	.072	1.588	1.015	.411	3.09
Average	.186	.897	1.599	1.374	1.046	5.10
Percentage of total	3.65	17.58	31.34	26.93	20.50	100.0

The above table gives the amounts and percentages that were applied to grain and alfalfa on the porous sandy and gravelly soils, and it will be noted that as with the crops on the medium lava ash and clay soils, almost the entire demand for water occurred during the four months, May to August, inclusive, and that as with the less pervious soils, the greatest need for water also occurred during the month of June when almost one-third of the total amount was applied.

While it appeared to be the tendency with many of the plots for the largest application of water to produce the largest yield per acre, the increase in the yield was but in few cases proportional to the increase in the amount of water used. The highest and best use, therefore, was obtained from the water where the smaller amounts were applied. In order to illustrate this fact more clearly the following table has been compiled from the results secured from 27 one-tenth-acre plots of grain raised on the medium lava ash and clay soil of the Gooding Experiment Station:

Yield per acre, per acre-foot of water applied, and number of pounds of water applied per pound of grain.

	Crop.	Area.	Depth of water applied.	Yield. Per acre.	Yield. Per acre-foot of water applied.	Water applied per pound of grain.
		Acres.	*Feet.*	*Pounds.*	*Pounds.*	*Pounds.*
1	Blue stem wheat	0.172	0.00	436.00	Infinity.	....
2	.....do	.089	.533	1,123.59	2,108.05	1,287
3	.....do	.088	.713	1,397.72	1,960.33	1,384
4	.....do	.091	.842	1,824.17	2,166.47	1,252
5	.....do	.084	1.210	2,000.00	1,652.89	1,641
6	.....do	.092	1.435	2,010.00	1,400.69	1,937
7	.....do	.083	2.486	2,084.30	838.01	3,238
8	Sonora wheat	.195	.00	605.13	Infinity.	....
9	.....do	.088	.352	1,227.27	3,486.56	778
10	.....do	.088	.533	1,238.63	2,323.89	1,167
11	.....do	.086	.945	1,430.23	1,513.47	1,793
12	.....do	.089	1.10	1,932.58	1,756.89	1,544
13	.....do	.074	1.601	2,067.50	1,391.38	1,950
14	.....do	.089	2.355	2,101.12	892.19	3,041
15	Little club wheat	.176	.00	522.72	Infinity.	....
16	.....do	.088	.434	1,227.72	2,828.84	959
17	.....do	.089	.594	1,359.66	2,288.99	1,185
18	.....do	.091	.907	1,824.17	2,011.21	1,349
19	.....do	.088	1.091	2,102.27	1,926.92	1,408
20	.....do	.093	1.786	2,258.00	1,264.27	2,146
21	.....do	.074	3.01	2,635.13	875.45	3,099

This table shows the areas and the depths of application together with the yield per acre-foot of water used (without regard to area) and also the number of pounds of water that were required for the production of 1 pound of shelled grain. A careful inspection of the table clearly demonstrates the fact, that although there is a decided tendency for the larger applications to give an increased yield, the efficiency of the water is decreased very materially as the amount applied is increased. This shows clearly that with spring grains the best use is never obtained where only medium amounts are applied.

While, as has been stated, sufficient data have not yet been secured from which to establish a definite duty, it is certain that the proper duty can be definitely determined in this practical manner after three or more years' results have been secured. Some very valuable indications have already been worked out, however, and the reader is referred to the last biennial report of the Idaho State engineer for a more complete summary of the 1910 investigation. A general summary of the investigation will be published in a United States Department of Agriculture bulletin as soon as the investigation is completed.